Agricultural Outlook Forum
U.S. Department of Agriculture
February 21-22, 2008

Improving Water Quality Across the Landscape

Thomas J. Casadevall

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Improving Water Quality Across the Landscape

Thomas J. Casadevall

Regional Director

U.S. Geological Survey
Denver, Colorado

U.S. Department of the Interior
U.S. Geological Survey

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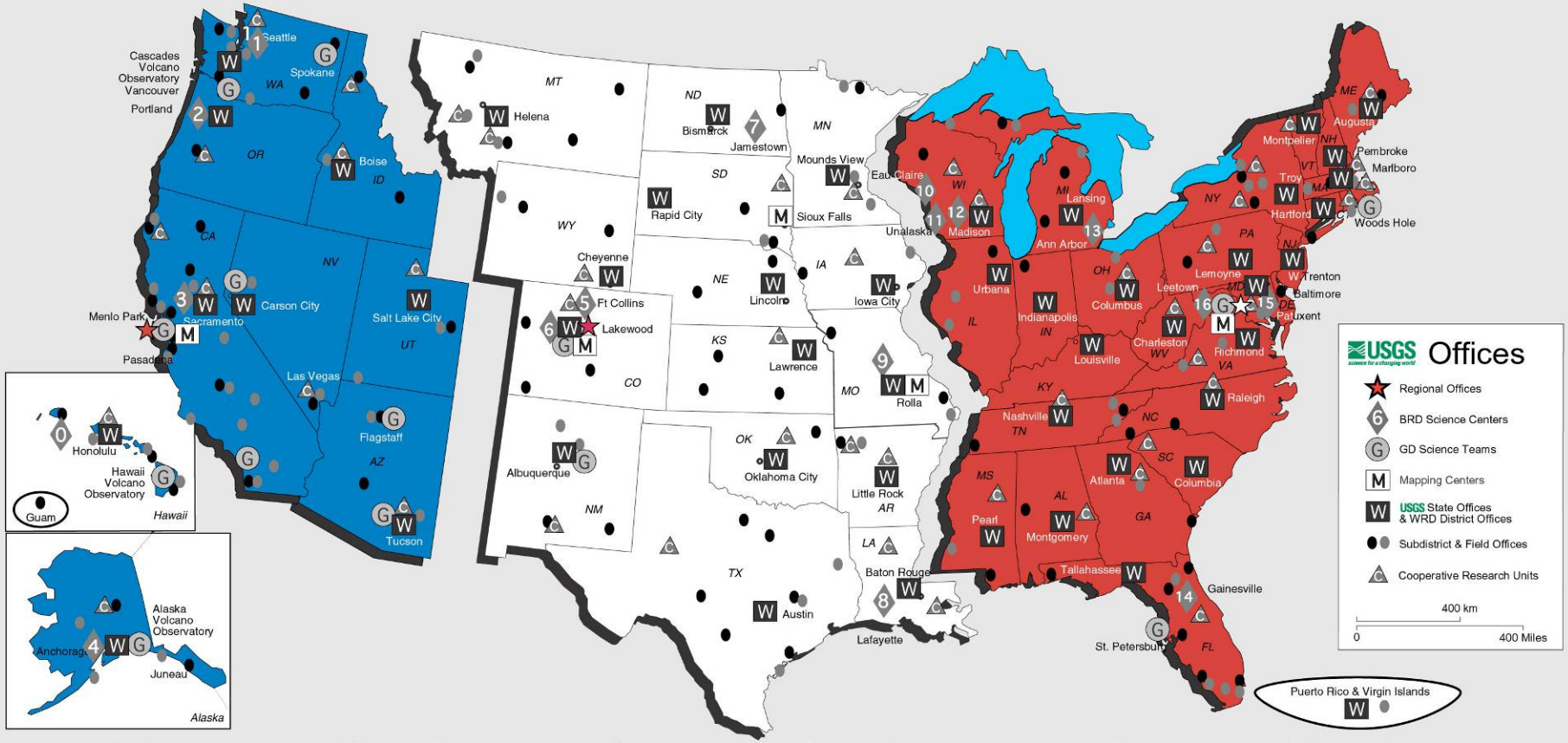
US Geological Survey Regions

Location of Major Offices



Western Region

Menlo Park, CA

0. Pacific Island Ecosystems Research Ctr.
1. Western Fisheries Research Ctr.
2. Forest & Rangeland Ecological Science Ctr.
3. Western Ecological Resesarch Ctr.
4. Alaska Biological Science Ctr.

G-Anchorage AK Alaska Volcano Observatory
G-Flagstaff AZ Flagstaff Field Center
G-Tucson AZ Tucson Field Office
G-Menlo Park CA Western Region
G-Hawaii Hawaii Volcano Observatory
G-Reno NV Reno Field Office
G-Vancouver WA Cascades Volcano Observatory
G-Spokane WA Spokane Field Office

Central Region

Lakewood, CO

5. Mid-Continent Ecological Science Ctr.
6. Ctr. for Biological Informatics
7. Northern Prairie Wildlife Research Ctr.
8. National Wetlands Research Ctr.
9. Columbia Environmental Research Ctr.

G-Lakewood CO Central Region
G-Golden CO National Earthquake Info Ctr.
G-Albuquerque NM Albuquerque Seismological Lab
M-Lakewood CO Rocky Mountain Mapping Center
M-Rolla MO Mid-Continent Mapping Center
M-Sioux Falls SD EROS Data Center

Eastern Region

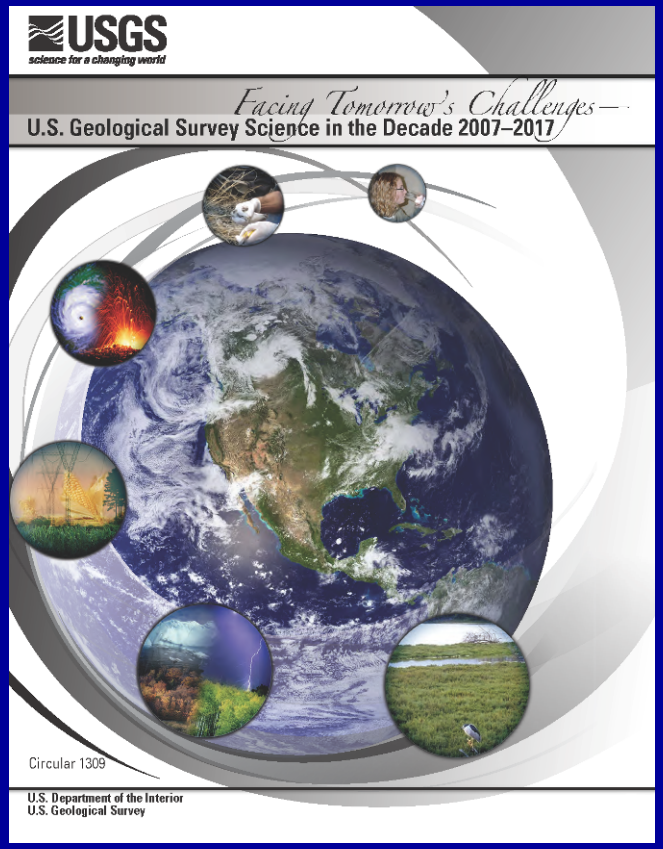
Reston, VA

10. Environ. Mgt. Tech. Ctr.
11. Nat'l Wildlife Health Ctr.
12. Upper Mississippi Science Ctr.
13. Great Lakes Science Ctr.
14. Florida & Caribbean Science Ctr.
15. Patuxent Wildlife Research Ctr.
16. Leetown Science Ctr.

G-Reston VA Eastern Region
G-St Petersburg FL Center for Coastal Geology
G-Woods Hole MA Woods Hole Field Center
M-Reston VA Mapping Applications Center

USGS Science Disciplines

- Biology
- Geology
- Geography
- Water
- Geospatial Information



Science Strategy 2007-2017

- Ecosystems
- Global Change
- Energy and Minerals
- Hazards
- Human Health
- Water Census
- Data Integration

USGS

USGS Research Interests related to Agriculture

- Evaluating Ag Effects on Terrestrial and Aquatic Ecosystems
- Watershed, Reservoir, Aquifer, and Wetlands Assessments
- Agricultural Contaminants (chemical, microbial)
  - Status and trends
  - Sources, transport, and fate
  - Predictive models
  - Emerging contaminants
  - Methods research and development
- Trends in Agricultural Land and Water Use
- Global Climate Change Research (Carbon Cycling)
- Geochemistry of Soils and Stream Sediments

USGS

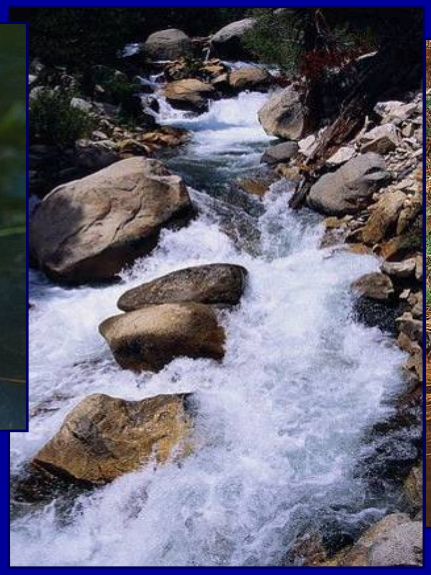
Assets USGS Brings

- Long-term monitoring, assessment, and research infrastructure for collaborative study
- Interdisciplinary expertise and capability nationwide, internationally
- Collaborations
  - Scientist to scientist
  - Program to program
  - Regional/National

USGS

Breadth of Studies

- Field Monitoring/Assessment
- Analytical Methods/Controlled Lab Research
- Source Pathways/Watershed Process, Transport, Fate
- Human/Biota Effects



USGS

Reports

USGS
science for a changing world

EFFECTS OF ANIMAL FEEDING OPERATIONS
ON WATER RESOURCES AND THE
ENVIRONMENT--

Proceedings of the technical meeting,
Fort Collins, Colorado, August 30 – September 1, 1999

U.S. Geological Survey
Open-File Report 00-204

U.S. Department of the Interior
U.S. Geological Survey

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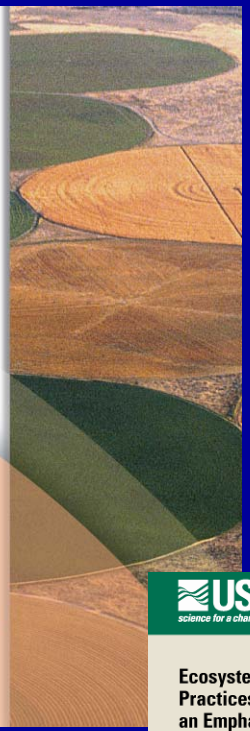
Environmental Effects of Agricultural Practices—

Summary of Workshop Held on June 14–16, 2005



Scientific Investigations Report 2006–5215

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USDA
Farm Service Agency

**The Conservation Reserve Program–
Planting for the Future:
Proceedings of a National Conference,
Fort Collins, Colorado, June 6–9, 2004**

Scientific Investigations Report 2005–5145

U.S. Department of the Interior
U.S. Geological Survey

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Ecosystem Services Derived from Wetland Conservation Practices in the United States Prairie Pothole Region with an Emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs

NRCS
USDA
Farm Service Agency

Professional Paper 1745

Draft

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Fact Sheets

USGS science for a changing world

Natural Resources Canada | Ressources naturelles Canada

Natural and Man-Made Chemicals in North American Soils—Continental-Scale Pilot Study Completed

The U.S. Geological Survey and the Geological Survey of Canada recently completed a continental-scale pilot study for a proposed geochemical survey of North American soils. This survey will provide baseline soil chemistry data against which future changes in soil composition can be measured and that can be used by Federal, State/Provincial, and local agencies when making risk-assessment and land-use decisions. Agencies that will use these data include

- *U.S. Department of the Interior*
- *Natural Resources Canada*
- *U.S. Environmental Protection Agency*
- *Environment Canada*
- *Centers for Disease Control and Prevention*
- *Health Canada*
- *State, Provincial, and local departments of environmental protection and health departments*

Introduction

Soil is a critical natural resource that plays a key role in determining human health and ecosystem integrity, supporting food production and the natural recycling of carbon and essential nutrients in the environment. Soil also stores water used by plants in dry seasons. On the other hand, many communities dispose of solid and liquid wastes from households and from agricultural and industrial processes by dumping them onto the soil. Although soil is so important in our everyday lives, our knowledge of the concentration and distribution of naturally occurring and man-made chemicals in the soils of North America is very limited. As a result, establishing standards for soil clean-up levels, evaluating the effects on human health of chronic exposure to contaminated soils, and determining the impact of new land-use practices on the environment are extremely difficult without baseline data for comparison.

In order to improve our understanding of the types of chemicals and elements that are normally found in soil and the location and causes of elevated or depleted levels, the U.S. Geological Survey (USGS), the Geological Survey of Canada (GSC), and the Mexican Geological Survey (Servicio Geológico Mexicano, or SGM) are collaborating on the North American Soil Geochemical Landscapes Survey, a project to survey the chemical composition of soils over all of North America. The goal of this project is to map the concentrations and spatial distribution of elements and selected chemicals across North America.

Such a geochemical survey could be used by Federal, State/Provincial, and local agencies as a baseline for risk-based assessments of contaminated land and in determining the impact of land-use decisions (such as timber harvests, mining, industrial activities, or landfill permits) on the soil, the environment, and human health. The survey could also be used as a baseline in writing environmental impact statements for new projects that may affect our environment or to monitor the effect of ongoing activities on soil composition in surrounding communities. The survey is intended to replace older, outdated, and incomplete data that are currently being used by land-management, regulatory, and public health agencies.

Project Status

The North American Soil Geochemical Landscapes Survey was officially launched in 2003 at a workshop attended by 112 representatives from more than 40 North American governmental agencies, academic institutions, environmental consultants, and the medical community. At the workshop, recommendations regarding study design, sampling procedures, and analytical methods for the continental-scale survey were adopted. Overall, it is estimated that more than 40,000 soil samples will be collected and tested for more than 40 elements and chemical compounds during the multiyear project.

A USGS scientist collecting soil samples in southern New Mexico. Samples were collected approximately every 40 km along two transects.

U.S. Department of the Interior
U.S. Geological Survey

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Fact Sheet 2006–3115
October 2006

USGS science for a changing world

Nitrogen in the Mississippi Basin—Estimating Sources and Predicting Flux to the Gulf of Mexico

Nitrogen from the Mississippi River Basin (fig. 1) has been implicated as one of the principal causes for the expanding hypoxic zone that develops each spring and summer on the Louisiana-Texas shelf of the Gulf of Mexico. Hypoxia refers to dissolved oxygen concentrations less than 2 mg/L (milligrams per liter). Hypoxia can cause stress or death in bottom-dwelling organisms that can not leave the zone. The midsummer extent of the hypoxic zone has more than doubled since it was first systematically mapped in 1985 (Rabalais and others, 1999). The largest hypoxic zone measured to date occurred in the summer of 1999, (fig. 2) when its size was reported to be 20,000 km² (square kilometers), or about the size of the State of New Jersey (Rabalais, 1999). In the summer of 2000, following drought conditions in the basin, the area of the hypoxic zone was about 4,400 km², one of the smallest sizes measured to date (Rabalais, 2000).

Figure 1. Mississippi River drainage basin, major tributaries, and areal extent of 1999 midsummer hypoxic zone.

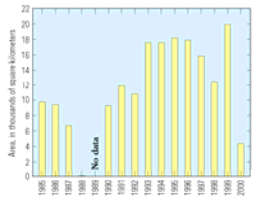

Figure 2. Area of hypoxic zone, 1985–2000 (source: N.N. Rabalais, Louisiana Universities Marine Consortium).

Two conditions are necessary for the formation of hypoxia—stratification of the water column in the Gulf and the presence of organic matter to consume oxygen. The Mississippi River produces both conditions through large inputs of freshwater and nutrients. High streamflow in the spring and summer provides a large influx of freshwater, which promotes stratification in the Gulf with warmer, less dense water overlying colder, more dense salt water. Nutrients from the Mississippi River fuel the production of algae in the surface water of the Gulf. Organic material from the algae and other organisms settles into the bottom water of the Gulf where it is decomposed by bacteria, which consume oxygen in the process. Stratification blocks the replenishment of oxygen from the surface, and hypoxia develops. Hypoxia may persist until late fall when stratification breaks up because of reduced freshwater inputs, cooler temperatures, and mixing by storms.

One of the principal causes for the increasing size of the hypoxic zone is believed to be the increasing supply of nitrogen, particularly nitrate, delivered to the Gulf each year from the Mississippi River Basin. Nitrate concentrations have increased several fold during the past 100 years in streams draining some parts of the Mississippi Basin, and the annual delivery of nitrate from the Mississippi River to the Gulf has nearly tripled since the late 1950's (Goolsby and others, 1999). The increased delivery of nitrate can

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USGS Fact Sheet 135–00
December 2000

USGS science for a changing world

Investigating the Environmental Effects of Agriculture Practices on Natural Resources

Scientific Contributions of the U.S. Geological Survey to Enhance the Management of Agricultural Landscapes

The U.S. Geological Survey (USGS) enhances and protects the quality of life in the United States by advancing scientific knowledge to facilitate effective management of hydrologic, biologic, and geologic resources (http://www.usgs.gov). Results of selected USGS research and monitoring projects in agricultural landscapes are presented in this Fact Sheet. Significant environmental and social issues associated with agricultural production include changes in the hydrologic cycle; introduction of toxic chemicals, nutrients, and pathogens; reduction and alteration of wildlife habitats; and invasive species. Understanding environmental consequences of agricultural production is critical to minimize unintended environmental consequences. The preservation and enhancement of our natural resources can be achieved by measuring the success of improved management practices and by adjusting conservation policies as needed to ensure long-term protection.

Interdisciplinary USGS research and monitoring plays a key role in providing independent scientific information needed for the understanding, management, and mitigation of short- and long-term effects of agricultural practices on natural and human resources. USGS scientific information is used by a variety of stakeholders that include public, private, and special-interest groups, agricultural producers, and State, Tribal, and Federal governments that manage the Nation's natural resources.

Over half of the land in the Nation's lower 48 States is in crops, pasture, and range (Lubowski and others, 2006). By 2004, half of the original wetlands in the lower 48 states was converted to mostly agricultural uses (Claassen, 2004). From the start of European settlement until 1954, about 42 percent of original wetlands were drained and filled and used for settlement and agriculture. From 1954 to 1974, wetland loss was reduced by half (Wiebe and Golleron, 2006). Nearly all of the pre-settlement forest, prairie, and wetland areas in the Midwestern and Great Plains States have been converted to or affected by agricultural production.

Technological advances in agricultural production methods over the past 60 years have dramatically changed the character of agriculture. The number of farms declined from 6.8 million in 1935 to 2.1 million in 2002. Whereas small family-owned farms once produced the majority of the Nation's agricultural products, in 2003 small farms accounted for 91 percent of farms, but only 27 percent of total agricultural production. By 2002, half of the farm sales came from 2 percent of farms and 11 percent of the land in farms (Wiebe and Golleron, 2006). Support of this intensified agriculture requires larger fields, reduction in the types and rotations of crops, and greater reliance on agrichemicals (nitrogen, phosphorus, pesticides) to maintain high productivity.

Significant environmental and social issues associated with agricultural production include changes in the hydrologic cycle; introduction of toxic chemicals, nutrients, and pathogens; reduction and alteration of wildlife habitats; and invasive species. Understanding environmental consequences of agricultural production is critical to minimize unintended environmental consequences. The preservation and enhancement of our natural resources can be achieved by measuring the success of improved management practices and by adjusting conservation policies as needed to ensure long-term protection.

Science Issues and Needs Identified by the USGS, as Related to Environmental Impacts of Agricultural Practices

- Effects of land-use change and habitat fragmentation on wildlife.
- Balancing conflicting urban and agricultural water demands.
- Influence of air and ground-water and surface-water interactions on water quality.
- Effects of agricultural drainage, irrigation, and return flow on water quality.
- Development and implementation of innovative farming techniques to conserve soil and water and to improve water quality.
- Effects of genetically modified organisms on native species and habitats.
- Tools for identifying sources of agricultural contamination and rapid assessment techniques.
- Effects of pesticides, nutrients, and sediments on fish and wildlife health and habitat quality.
- Effects of watershed characteristics—soils, riparian forests, and wetlands—effects on nutrient uptake, retention, and cycling.
- Transport and fate of endocrine-disrupting compounds, veterinary antibiotics, feed additives, hormones, and pathogens in terrestrial and aquatic ecosystems.

Land cover map of the conterminous United States from early 1990s data (Vogelmann and others, 2001; Nakagaki and Wolock, 2005).

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Fact Sheet 2007–3001
January 2007

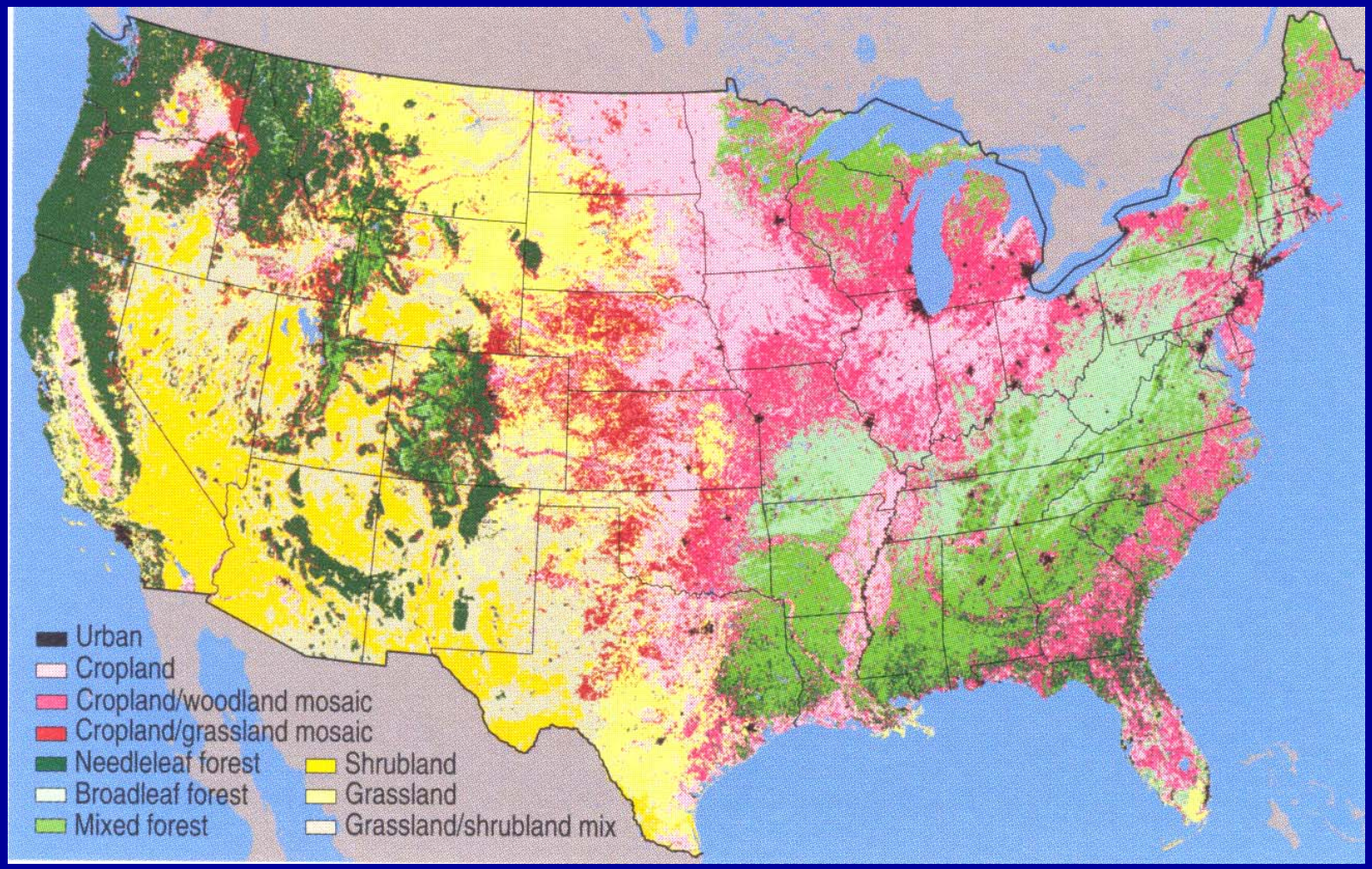
USGS

Stakeholders

- DOI Bureaus
- Tribes
- EPA
- USDA Bureaus
- Interstate Compact Organizations
- State Agencies and Organizations
- Farm Interest Groups

USGS

Land Use



USGS

North American Soil Geochemical Landscapes Project

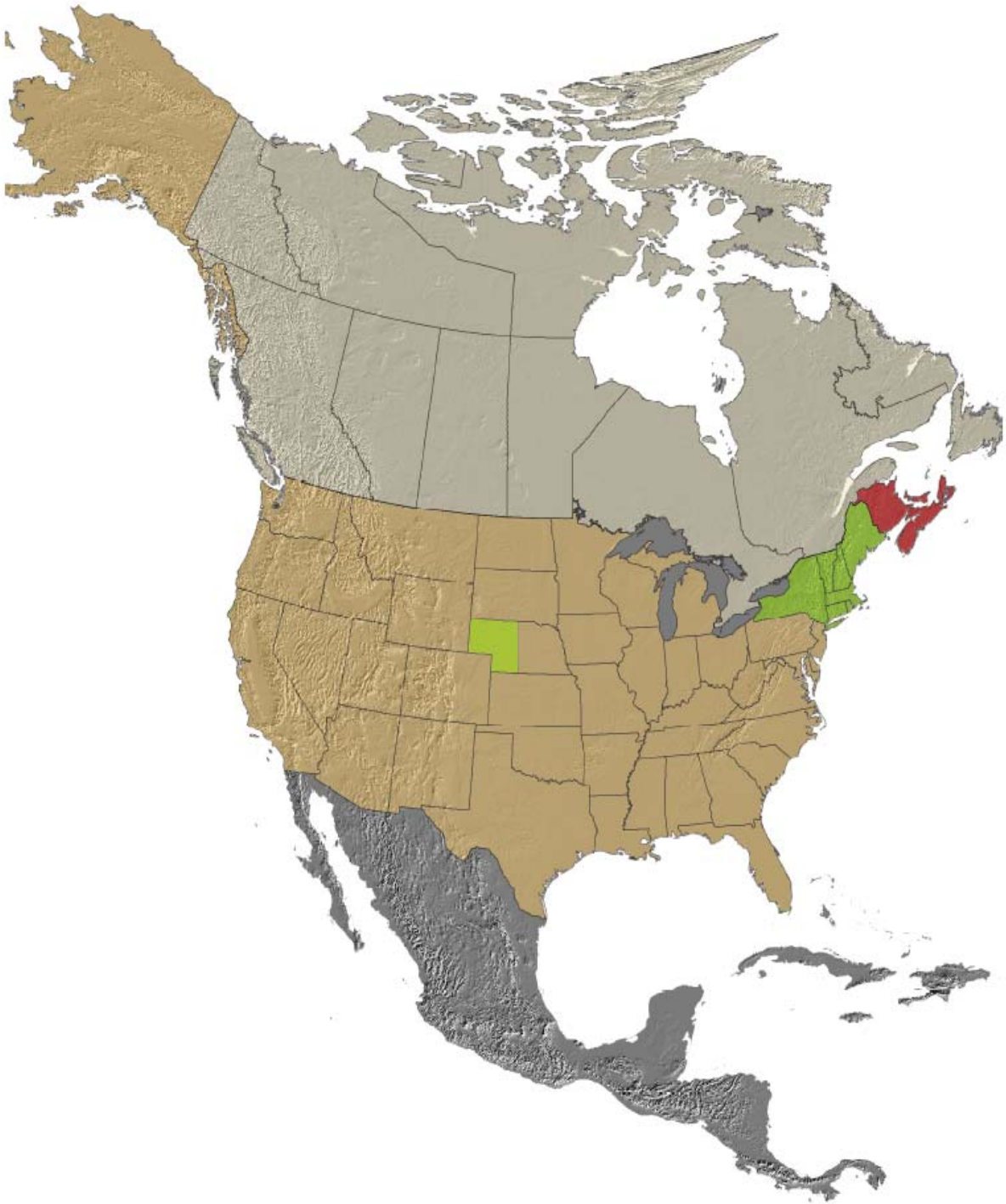
13,215 sites in N. America, density of 1 site/1,600 km^2

States/provinces completed in 2007:

NB, NS, PE in Canada

ME, NH, VT, CT, RI, MA, NY, ~50% of NE in US

USGS



Agricultural Water Use Trends 1950-2000

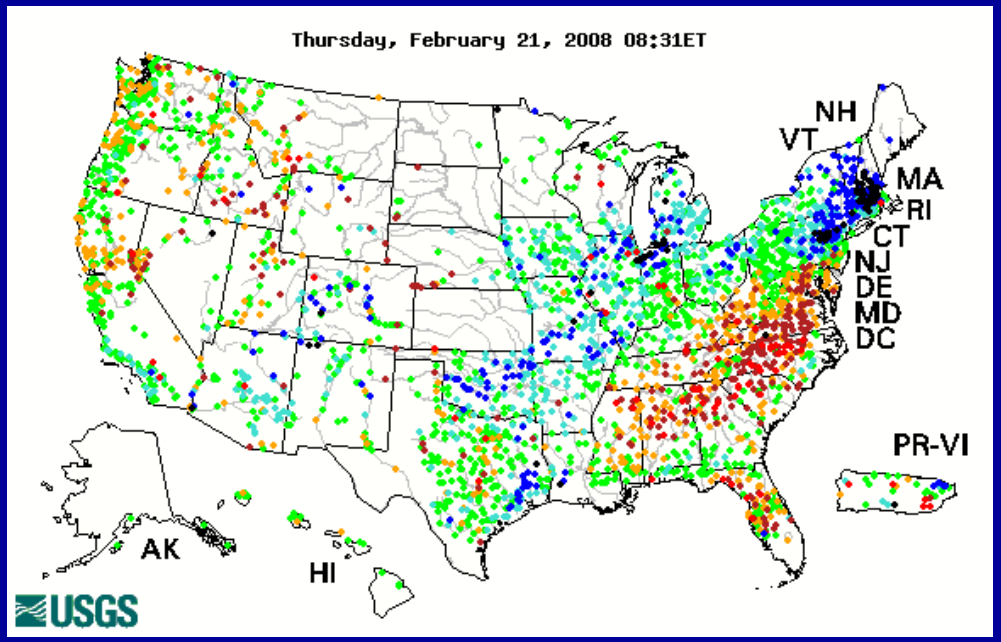
- Surface water for irrigation dropped 20%
  Ground-water use tripled
- Irrigated acres doubled from 1950 to 1980 and has remained constant since 1980
- Average irrigation rate dropped from 3.55 acre-ft/acre to 2.48 acre-ft/acre
- USGS *National Water Use Report* in mid-2008 breaking out use from urban growth vs. agricultural and ecosystem services

USGS

http://waterdata.usgs.gov/nwis

Real-time streamflow

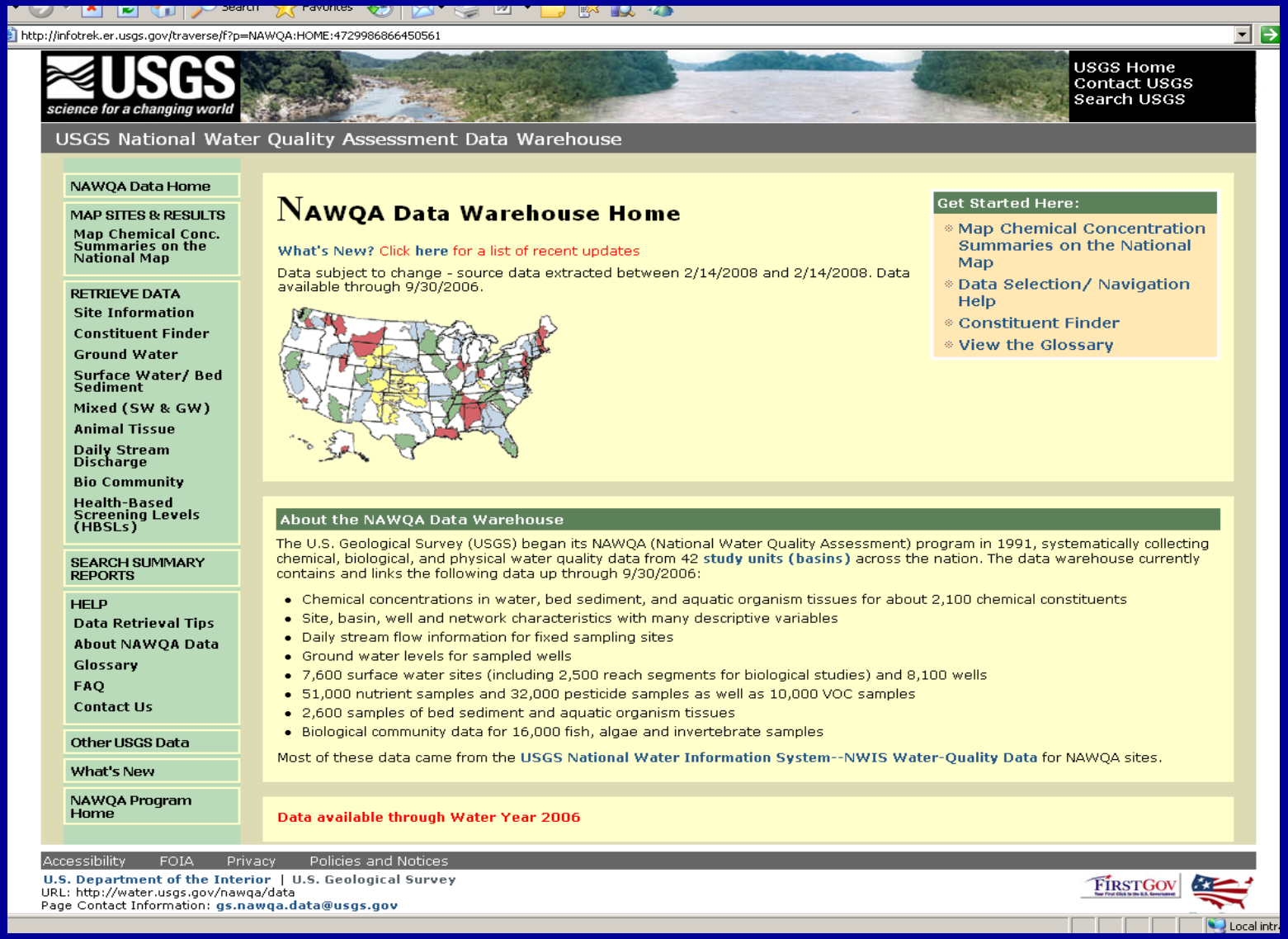
Real-time Data
- **Surface water**
- **Ground water**
- **Water quality**



Water-Quality Data for Virginia--
- Real-time data at 111 sites
- Daily data at 167 sites
- Water quality, stream sediment, biological tissue samples at 3,308 sites

USGS

USGS NAWQA Data Warehouse
(many sites attributed to agricultural settings)



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U.S. Geological Survey

Iowa CREP

USGS

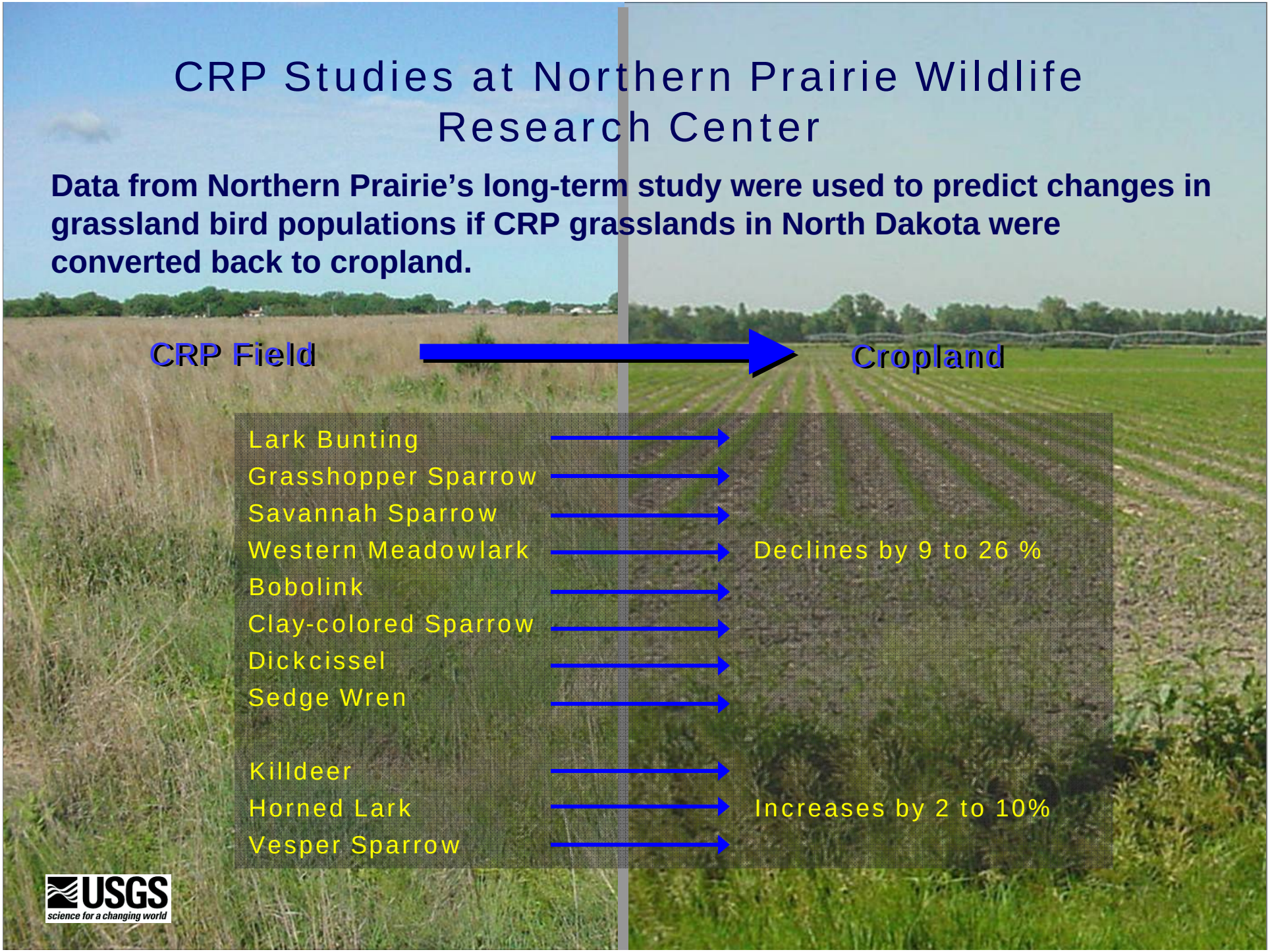
Iowa CREP

- Assess the effect of CREP treatment wetlands on water quality in Iowa
- Show how nutrient loadings from tile-drain agriculture can be reduced and how additional wetlands benefit wildlife
- Monitor the timing and concentrations of nutrients (link to spring pulses or when fertilizers are applied)
- Partner with FSA, FWS R-3, Iowa State agencies, USGS

USGS

CRP Studies at Northern Prairie Wildlife Research Center

Data from Northern Prairie's long-term study were used to predict changes in grassland bird populations if CRP grasslands in North Dakota were converted back to cropland.



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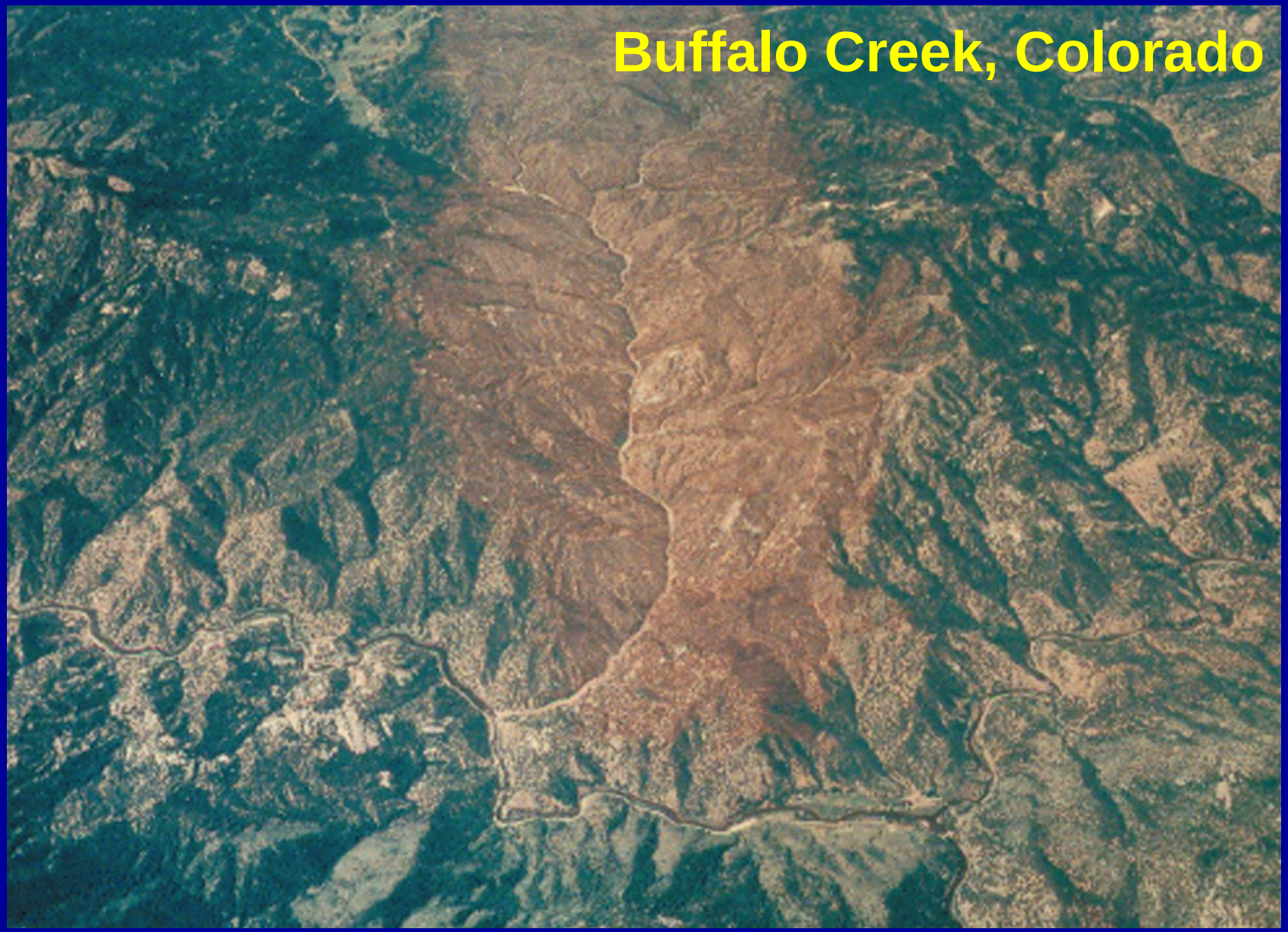


USGS

Buffalo Creek area, Colorado

- Buffalo Creek area, Pike National Forest, Colorado, has suffered several major fires in the past decade
- USGS and USFS scientists have monitored the impacts of stream runoff, sediment, and water quality in these fire-affected landscapes
- Evaluate post-fire treatments

USGS

Confined Animal Feeding Operations

USGS

CAFOs

- Develop analytical methods for:
  - Antibiotics and hormones used in animal agriculture
  - Indicator bacteria and pathogens linked to animal agriculture
- Research and studies to evaluate occurrence of antibiotics and hormones in streams and ground water from livestock areas, manure application to fields, and effects on aquatic life
- Research and studies to identify sources of bacteria (municipal or domestic sewage vs. animal agriculture)

USGS

Fort Cobb Reservoir and Drainage Basin

USGS

Fort Cobb drainage, Oklahoma

- Groundwater is highly contaminated and Ft. Cobb reservoir is eutrophic
- USGS studying impacts of agricultural practices (row crops, pasture grazing, CAFOs) on streams and reservoir quality
- Determining the sources of nutrients to the reservoir to guide management agencies in development of best management practices

USGS

Discovery Farms, Wisconsin

Discovery Farms, Wisconsin

- Working in partnership with Wisconsin State agencies, NRCS, dairy producers, and farm associations
- USGS is conducting water quality monitoring on various farms to understand how farming practices such as timing of fertilizer application affects water quality
- Just beginning a similar study in Nebraska

USGS

Sacramento River, California

USGS

Sacramento River, California

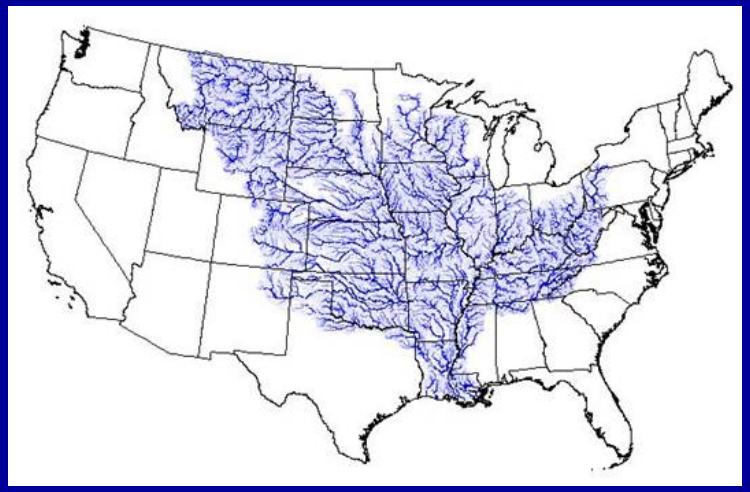
- USGS, in cooperation with State agencies and local producers, is monitoring the impacts of agricultural practices in the Central Valley of California

- Quantifying the flow of nutrients into the San Jaoquin – Sacramento delta system

USGS

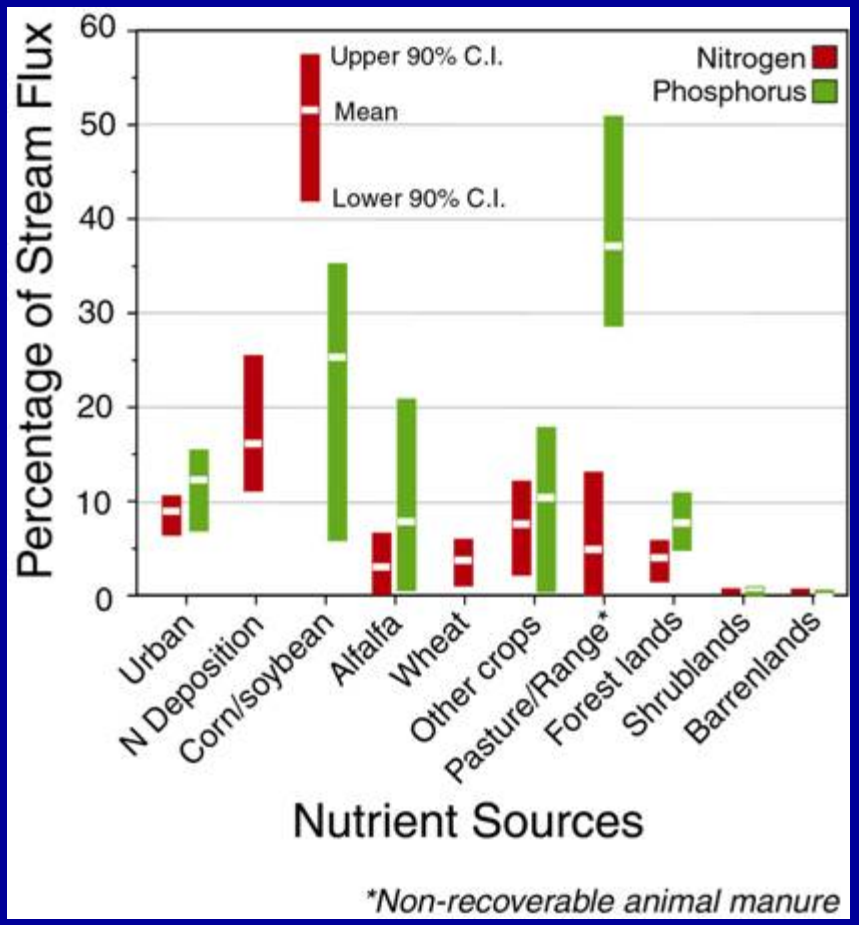
SPARROW Water-Quality Model
SPAtially Referenced Regression on Watershed Attributes

Mississippi/Atchafalaya River Basin



Nitrogen and phosphorus are affected by different sources and land uses and require different management practices

Nutrients Delivered to the Gulf



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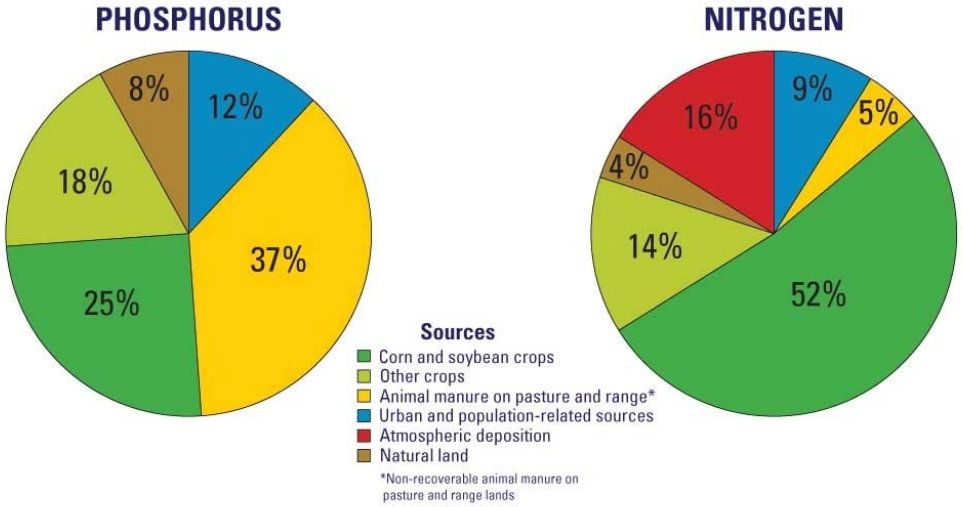
Sources of nutrients delivered to the Gulf of Mexico



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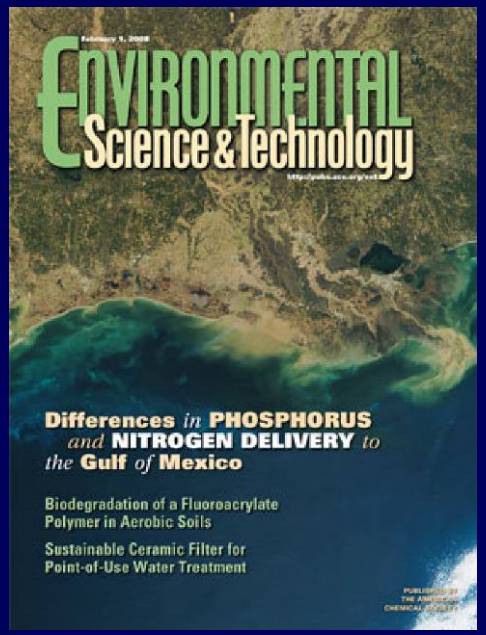
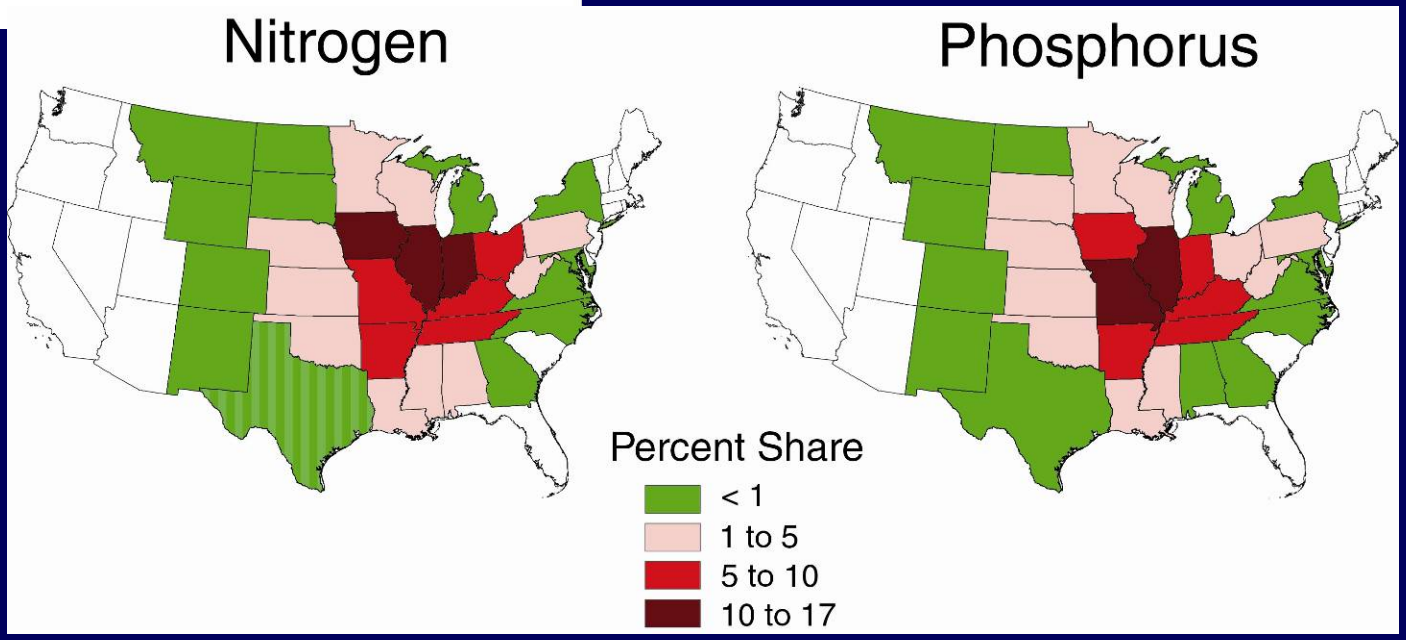
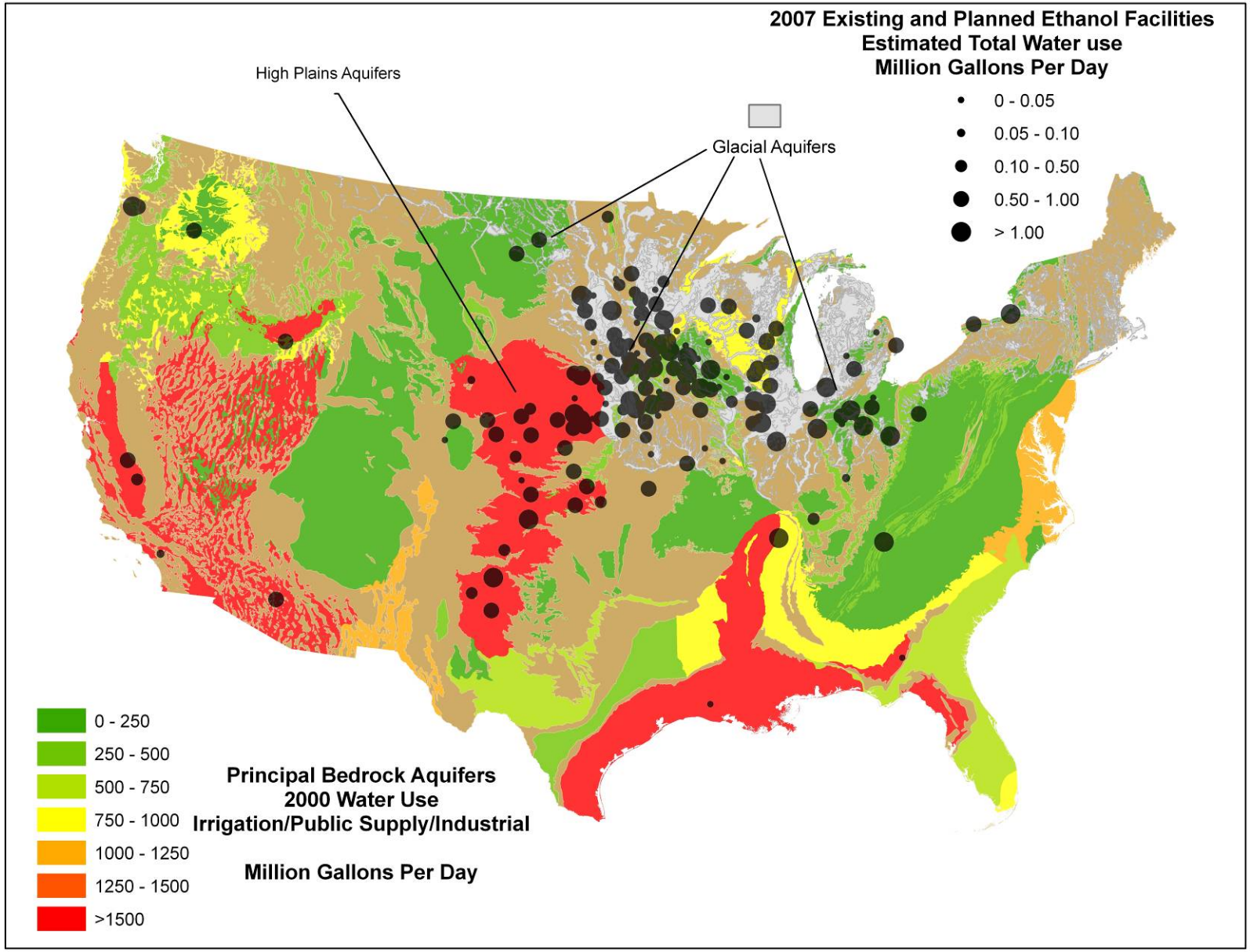
U.S. Geological Survey






2007 Existing and Planned Ethanol Facilities
Estimated Total Water use
Million Gallons Per Day
0 - 0.05
0.05 - 0.10
0.10 - 0.50
0.50 - 1.00
> 1.00
High Plains Aquifers
Glacial Aquifers
0 - 250
250 - 500
500 - 750
750 - 1000
1000 - 1250
1250 - 1500
>1500
Principal Bedrock Aquifers
2000 Water Use
Irrigation/Public Supply/Industrial
Million Gallons Per Day

USGS

Ethanol

- Ethanol plants are concentrated in the Corn Belt
- Water for processing ethanol and for growing more corn depend heavily on glacial aquifers and from the High Plains aquifers- already competing uses for this groundwater
- Water-quality concerns with increased corn acreage include degradation to streams from increased nutrient loading, pesticide loading, and decreased wildlife habitat
- Effects can be local and far downstream (Gulf of Mexico, Chesapeake Bay)

USGS

Responding to Agriculture Partners

"Sound scientific data and improved technology are increasingly necessary in order to effectively resolve the complex resource issues facing farmers and ranchers."

American Farm Bureau Federation, 2001

USGS

Thank you!

USGS

Summary Slide

- Ecosystem Services

USGS

Ecosystem Services

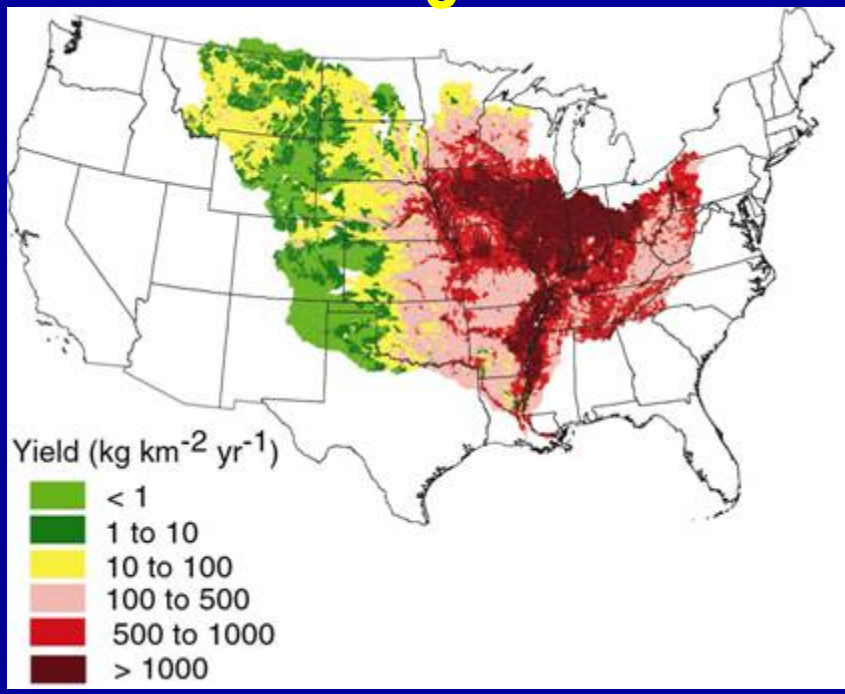
Services	Studies
Floodwater Storage	Estimate of water storage potential
Biodiversity/Habitat Quality	Floristic quality, taxon richness, habitat suitability
Erosion, Sedimentation and Nutrient Loading Potential	Sedimentation and nutrient loading for wetlands in cropland, restored grassland and native prairie
Carbon Sequestration	Estimates of soil and wetland vegetation carbon stocks
Greenhouse Gas Emissions Reduction	Comparison of rates of reduction greenhouse gas emissions from wetlands in cropland, restored grassland and native prairie

USGS

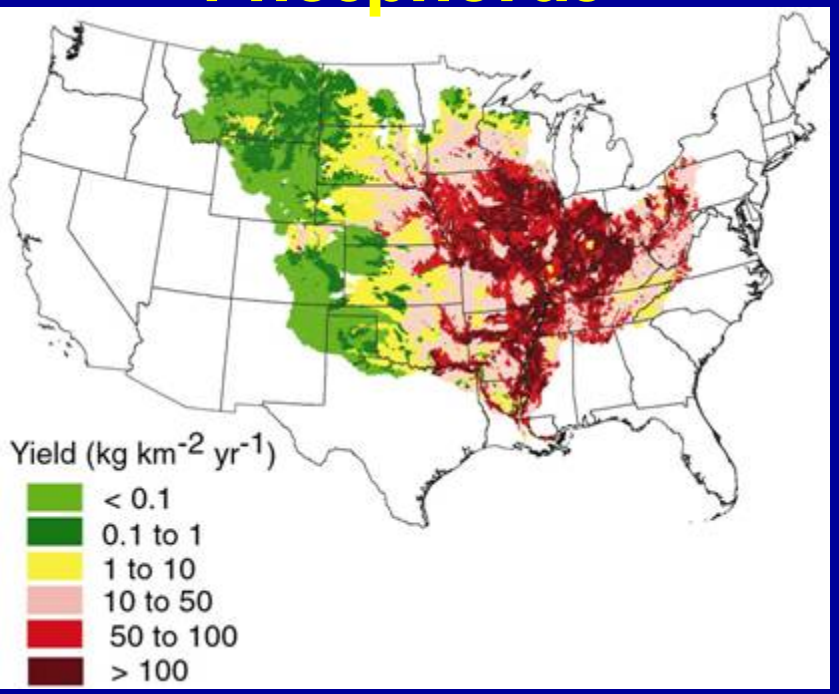
Nutrient mass delivered to the Gulf of Mexico

Many Midwestern and Eastern watersheds have higher "delivered yields"

Nitrogen



Phosphorus



USGS

USDA 84th Agricultural Outlook Forum

Energizing Rural America in the Global Marketplace

Conservation: Environmental Quality and Agriculture

USGS

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SGM
Servicio Geológico Mexicano

The North American Soil Geochemical Landscapes Project

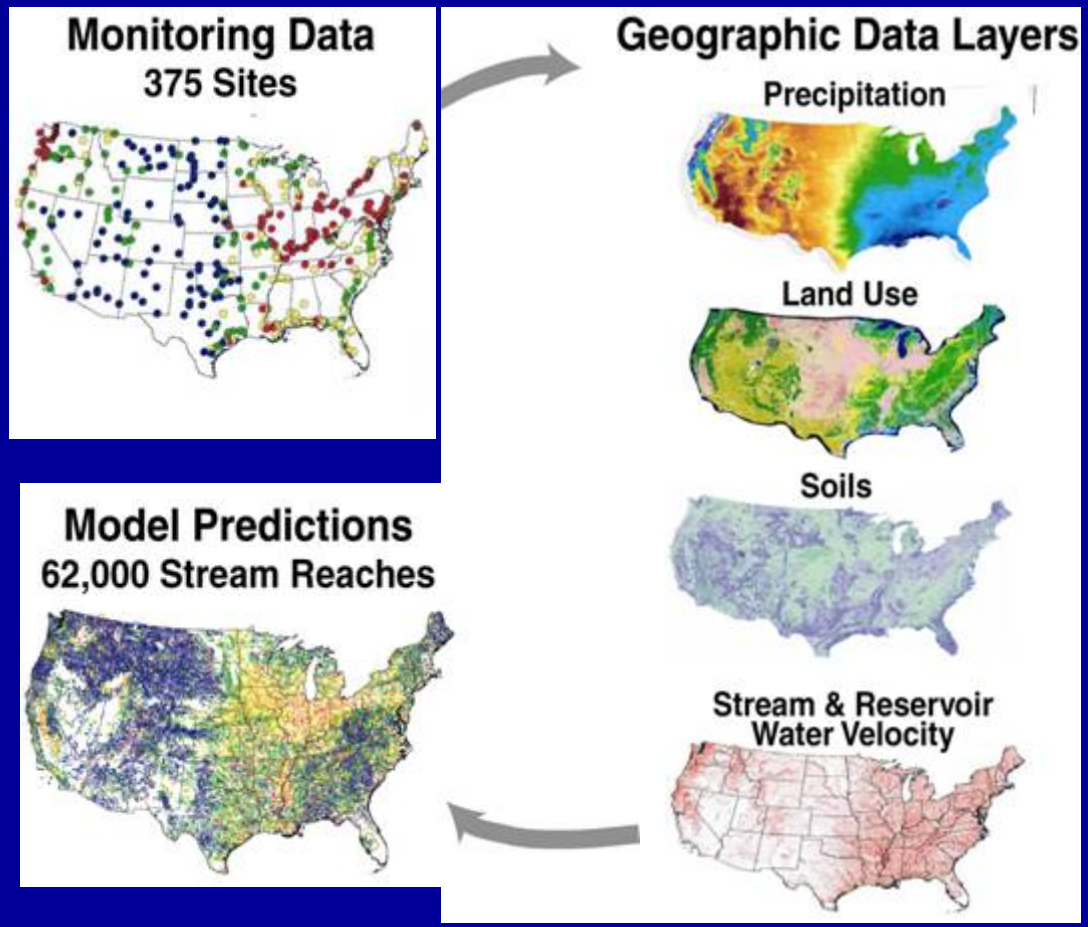
Natural Resources Canada | Ressources naturelles Canada

Canada

SPARROW Water-Quality Model

SPAtially Referenced Regression on Watershed Attributes

http://water.usgs.gov/nawqa/sparrow



- Depends on statistical regression of spatial data describing pollutant sources and in-stream water-quality measurements and a mass balance model of watersheds
  - agricultural land uses
  - nutrient inputs from crop and livestock production
  - urban land uses
  - atmospheric deposition
- Predicts mean annual loads/concentrations (and uncertainties) in streams for 1992 (and simulated 2002)

U.S. Department of the Interior
U.S. Geological Survey

Almond orchard, California

USGS

Almond orchard, California

- Peak impacts of agricultural practices on water quality often occur during flow events
- USGS NAWQA project uses a dye tracer study to estimate travel times of agricultural contaminants (spray pesticides and fungicides) to local creeks and into rivers

USGS